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ABSTRACT

This curriculum evaluation study involved a group of 989 twelfth-grade students who participated in a given curriculum for four years. Effects of interaction between curriculum and such variables as teachers' bias, type of school, sex of student, and specific subject matter taught as related to achievement were sought. Schools included city academic, rural-kibbutz, and agricultural. Students were divided into groups designated by the curriculum used. Of these, 408 were in the Biological Sciences Curriculum Study (BSCS) curriculum, using the Israeli-adapted Yellow Version. The second group of 581 students was the non-BSCS group. Fifty different teachers were involved and divided into two groups, the BSCS supporters and the non-supporters, based on response scores from the Blankenship Attitude Inventory. A multiple choice test, with KR = 0.79, was used to measure achievement. Statistical analyses included means, standard deviations, one-, two-, and three-way analyses of variance and t-tests. Considerable significant differences were found in school type, with achievement in agricultural schools much lower. Males outscored females in total results. Substantial and significant differences, all in favor of the BSCS students, were identified. (EB)

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THE EFFECT OF THE TEACHERS' CURRICULAR BIAS, THE KIND OF CURRICULUM STUDIED AS WELL AS THEIR INTERACTION ON STUDENTS' ACHIEVEMENT IN HIGH SCHOOL BIOLOGY

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Several studies have attempted to compare the outcomes of studying a BSCS biology with those of studying conventional high school biology (e.g. 1,2) or similarly, the outcomes of studying a research oriented high school advanced biology and a conventional text book centered advanced course (e.g. 3).

In most of these studies very little differences were found between experimental and control groups. Many explanations have been offered for this non significant differences. One possible reason, namely the relatively short period of exposition to the different programs has not been emphasized. Another, namely the possibility that some teachers teach the "new" program just like another text book without adopting the approach advocated by the new curriculum has been suggested but, to my best knowledge, never empirically studied.

The present study is different than most curriculum evaluation studies in the following respects:

a. It deals with the effect of studying a particular curriculum by the same students for four consecutive years.
b. It attempts to answer one of the open questions in curriculum evaluation, namely, what is the relative effects of the nature of a curriculum, on the one hand, and the teachers' bias toward the nature of a particular curriculum, on the other hand, on students' achievement.
c. It tries to identify significant interactions between the effects of a particular curriculum and certain intervening variables such as the teachers' curricular bias, the type of school, the sex of students and the specific subject matter topics, as related to achievement.

Procedure

The sample consists of 989 twelfth grade students in three different types of school in Israel namely city academic (N=542) rural-kibbutz (N=98) and agricultural (N=349). Of these,408 were studying the Israeli Adaptation of the BSCS program which follows the local adaptation of the Yellow version in grades 9 to 11 and selected portions of the BSCS Second Course Interaction of Experiments and Ideas in the twelfth grade. This

group will be designated as BSCS. The second group consisted of 581 student similar in all aspects to those of the first group, who were studying a non-BSCS curriculum. This group will be designated as non-BSCS.

These 989 students were studying in 48 different schools, taught by 50 different teachers. On the basis of their responses to the Blankenship Attitude Inventory the teachers were divided into two groups. The first group (N=24) designated as BSCS Supporters consisted of all the teachers who scored above the national mean of 30.70 (the highest possible score is 46). The second group (N=26) designated as Non-Supporters consisted of all the teachers who scores below 30.70 on the Blankenship Inventory.

A special 30 items multiple choice test was constructed for the purpose of measuring achievement. In constructing the test it was attempted to include items which reflect the major content areas covered by both the BSCS and non-BSCS curricula. Items which meet these requirements were selected from various recognized sources. (For instance, about half of the items were taken from CUEBS Publication No. 20). The selected items were pretested on samples not included in the present study and only items with point-biserial indices above 0.3 were included in the test used at the present study. The test was administered to all subjects by their teachers in April 1973. The KR-20 reliability was 0.79.

The following statistical analyses were undertaken: Means, standard deviations, one way, two way and three way analyses of variance, t-tests.

Findings

Table 0 presents the achievement of the whole sample.

Table 0: Achievement in various topics and in the total test (N=989)

Topic	No. of items	Mean raw score	Student deviation	Percent correct
Human biology	4	2.1	1.0	51
Botany	8	4.8	1.9	59
Zoology	8	4.3	1.7	54
Heredity	5	2.2	1.4	44
Statistics	2	0.4	0.6	18
Other topics	3	1.5	0.9	51
Knowledge	10	5.0	1.9	50
Comprehension	11	5.7	2.1	51
Higher abilities	9	4.5	2.0	50
Total score	30	15.2	4.9	51

Since in most topics as well as in the total test the mean percentage score is around 50 the test may be considered as having an adequate discrimination power.

The exceedingly low achievement in statistics is, in part, a result of the fact that in many schools this topic has hardly been studied at all. The relatively high level of achievement in botany on the one hand and the relatively low achievement in heredity on the other hand may either reflect the items difficulty or indicate a difference in the mastery level of different topics. In any event, the data reported in Table 1 may be used as a reference for the achievement data of the various groups which are reported below.

I Different types of schools

Table 1 compares the achievement in different types of schools.

Table 1: Achievement of students in different types of schools

Group	1 City N=542		2 Agricultural N=349		3 Kibbutz N=98		F	t		
Topic	$\bar{X}$	S.D.	$\bar{X}$	S.D.	$\bar{X}$	S.D.	df=2,983	1:2	1:3	2:3
Human biology	2.3	1.0	1.6	0.9	2.0	1.1	50.9**	10.4**	2.3*	3.1**
Botany	5.4	1.6	3.6	1.7	5.3	1.7	144.3**	16.4**	0.5	9.0**
Zoology	4.9	1.5	3.5	1.6	4.0	1.9	93.4**	13.6**	4.7**	2.4*
Heredity	2.5	1.4	1.7	1.3	2.5	1.5	37.1**	8.1**	0.2	4.7**
Statistics	0.4	0.7	0.3	0.5	0.4	0.6	1.4	1.3	0.3	1.1
Other topics	1.6	0.8	1.4	0.9	1.5	0.8	10.9**	10.8**	1.0	1.8
Knowledge	5.6	1.7	4.2	1.8	5.2	2.0	67.7**	11.7**	1.8	4.6**
Comprehension	6.4	1.8	4.5	1.9	5.5	2.4	102.6**	14.7**	3.6**	3.7**
Higher abilities	5.2	1.8	3.3	1.9	5.1	2.0	115.9**	14.6**	0.5	7.6**
Total score	17.2	4.0	12.1	4.3	15.8	5.3	157.2**	17.8**	2.4*	6.4**

* $p < 0.05$ ** $p < 0.01$

Table 1 reveals considerable and significant differences. The achievement in agricultural schools is much lower than that of students in the other two types of schools. Students in city schools achieved best. However, kibbutz school students achieved as well as city school students in botany, heredity and other topics. The similarity between kibbutz and city school students in higher abilities may indicate that the lower achievement of kibbutz students resulted from their lower level of achievement in tasks which required knowledge and comprehension. Perhaps kibbutz students are not putting as much effort as city students in learning facts and principles, but at the same time are adequately challenged by problem solving tasks. The low achievement of students in agricultural schools in Israel is not a surprise. Unfortunately we have no IQ data for the subjects in the present study. Yet, previous studies have shown that students in agricultural schools who sit for the matriculation examination at the end of the twelfth grade are not very much different in their IQ from other twelfth grade students. In any event, previous results have shown that even with IQ held constant by analysis of covariance, achievement of students in agricultural schools remains significantly lower (5,6). Undoubtedly, a lot of the variance is accounted for by the distinct school environment which exerts a negative effect on the learning atmosphere.

II Sex

Table 2 compares the achievement of males and females.

Table 2: Mean achievement scores of males and females

Topic ↓ / Group →	Males N=468 $\bar{X}$	S.D.	Females N=521 $\bar{X}$	S.D.	F df=2,983
Human biology	2.0	1.1	2.1	1.0	0.2
Botany	4.9	1.8	4.6	1.9	9.7**
Zoology	4.5	1.7	4.2	1.8	15.5**
Heredity	2.2	1.4	2.2	1.4	1.0
Statistics	0.4	0.6	0.3	0.6	2.2
Other topics	1.6	0.9	1.5	0.8	6.6**
Knowledge	5.1	1.9	4.9	1.9	6.9**
Comprehension	5.8	2.1	5.5	2.1	10.3**
Higher abilities	4.6	2.0	4.5	2.1	4.0*
Total Score	15.5	4.8	15.0	4.9	11.7**

* $p < 0.05$ ** $p < 0.01$

Table 2 shows that males outscored females in the total examination as well as in botany, zoology and other topics. Females achieved as well, however, in human biology and heredity. These results are significant because up to the present most evaluation studies have reported a small but consistent superiority to males without attempting to relate achievement to specific topics. Apparently topics such as heredity and human biology are interesting and appealing for girls to such an extent that they achieve as well as boys.

Table 3: Mean achievement scores of females and males in different types of schools

Topic ↓ / Group →	males			females			F
	T-1 N=229	T-2 N=177	T-3 N=6.?	T-1 N=313	T-2 N=172	T-3 N=36	interactio df=2,983
Human biology	2.3	1.6	2.1	2.3	1.6	2.0	0.1
Botany	5.3	4.1	5.3	5.4	3.0	5.4	12.9**
Zoology	5.1	3.8	3.9	4.8	3.1	4.2	3.7*
Heredity	2.3	1.9	2.5	2.6	1.5	2.5	7.0**
Statistics	0.4	0.4	0.4	0.3	0.3	0.4	2.3
Other topics	1.7	1.5	1.5	1.6	1.2	..6	2.8
Knowledge	5.6	4.6	5.1	5.5	3.8	5.3	5.1**
Comprehension	6.5	5.0	5.4	6.3	4.1	5.8	5.6**
Higher abilities	5.1	3.8	5.1	5.2	2.9	5.1	7.8**
Total score	17.2	13.3	15.6	17.1	10.8	16.1	10.0**

* $p < 0.05$ ** $p < 0.01$

T_1 - city; T_2 - agricultural; T_3 - heredity

Inspection of Table 3 reveals a number of significant interactions regardi the achievement of boys and girls in different types of schools. In botany girls achieved as well as bo.s in city and kibbutz schools, but significantly less in agricultural schools. A lower achievement of girls in agricultural schools is apparent all along the different topics as well as in the total score.

With regard to zoology boys outscored girls in city schools but girls outscored boys in kibbutz schools. This superiority of girls in kibbutz schools is apparent in most topics as well as in the total score.

Generally boys achieved as well as girls in city schools. These results indicate that the school environment exerts a significant effect on achievement. While the setting in kibbutz schools favors girls, the reverse appears to hold for agricultural schools.

III BSCS vs. non-BSCS

Table 4 compares the achievement of BSCS and non-BSCS students.

Table 4: Mean achievement scores of BSCS and non-BSCS students

Group → / Topic ↓	BSCS N=408 $\bar{X}$	S.D.	Non-BSCS N=581 $\bar{X}$	S.D.	F df=1,986
Human biology	2.2	1.0	1.9	1.0	20.3**
Botany	5.3	1.7	4.4	1.9	68.7**
Zoology	4.6	1.6	4.1	1.8	18.4**
Heredity	2.7	1.4	1.8	1.4	93.6**
Statistics	0.5	0.7	0.3	0.5	51.4**
Other topics	1.6	0.8	1.5	0.9	0.6
Knowledge	5.5	1.7	4.7	1.9	37.0**
Comprehension	6.1	2.1	5.3	2.0	37.2**
Higher abilities	5.4	1.9	4.0	2.0	120.7**
Total score	16.9	5.4	14.0	4.7	94.1**

* $p < 0.05$ ** $p < 0.01$

Table 4 reveals substantial and significant differences, all in favor of the BSCS students. Since this is the first study which compares achievement of BSCS and non-BSCS students after studying the different programs for a period as long as four years, the results are of special importance. They show that regardless of other benefits which may accure as a result of studying a BSCS type biology, as far as content learning is concerned the BSCS appears to be superior. The present results are in full agreement with the results obtained in a comparative

study of BSCS and non-BSCS students at the end of the tenth grade after studying a part of the whole course for two years (7).

It may be concluded that since the BSCS devotes a lot of time to the development of process skills the superior content achievement is an indication of a more meaningful learning. Whether or not Ausubel was partially right in raising doubts regarding the suitability of the BSCS Yellow Version as a course for tenth grade students (8) it appears to be highly suitable for a high school course which extends from the ninth to the twelfth grade.

Table 5 compares the achievement of BSCS and non-BSCS students in different types of schools.

Table 5: Mean achievement scores of BSCS and non-BSCS students in different types of schools

Group → / Topic ↓	BSCS T_1 N=291	BSCS T_2 N=42	BSCS T_3 N=75	Non-BSCS T_1 N=251	Non-BSCS T_2 N=307	Non-BSCS T_3 N=23	F interaction df=2,983
Human biology	2.3	1.7	2.1	2.3	1.6	1.8	0.5
Botany	5.5	3.5	5.5	5.3	3.6	4.9	0.9
Zoology	4.9	3.5	4.0	4.9	3.5	4.0	0.0
Heredity	2.9	1.3	2.7	2.0	1.8	1.7	16.9**
Statistics	0.6	0.5	0.4	0.2	0.3	0.4	3.2*
Other topics	1.5	1.5	1.6	1.7	1.3	1.3	4.3*
Knowledge	5.6	4.4	5.3	5.5	4.1	4.7	0.6
Comprehension	6.5	4.7	5.7	6.3	4.5	5.0	0.8
Higher abilities	5.7	2.9	5.3	4.6	3.4	4.5	12.2**
Total score	17.8	12.0	16.3	16.4	12.1	14.2	2.3

T_1 city; T_2 agricultural; T_3 kibbutz

* $p < 0.05$ ** $p < 0.01$

A number of statistically significant interactions were obtained. BSCS student outscore in tasks which require higher abilities (e.g. heredity). In agricultural schools the situation was reversed - the non-BSCS outscored the BSCS. In "other topics" and statistics, however, BSCS agricultural school students performed better than the Non-BSCS. Non-BSCS in city outscored the BSCS in "other topics". Significant interactions were revealed regarding sex and the type of curriculum. Moreover, a three way analysis of variance did reveal significant interactions amor , sex, type of school and type of curriculum regarding performance in statistics and "other topics" (See Tables 6 & 6a.).

Table 6: Achievement of BSCS and Non-BSCS male and female students

Group → / Topic ↓	BSCS				Non-BSCS				F interaction
	males N=194		females N=214		males N=274		females N=307		
	$\bar{X}$	S.D.	$\bar{X}$	S.D.	$\bar{X}$	S.D.	$\bar{X}$	S.D.	
Human biology	2.1	1.1	2.3	1.0	1.9	1.0	1.9	1.0	1.1
Botany	5.2	1.8	5.4	1.6	4.7	1.8	4.1	1.9	12.8**
Zoology	4.6	1.7	4.7	1.6	4.4	1.7	3.9	1.7	7.5**
Heredity	2.5	1.3	2.8	1.4	1.9	1.4	1.8	1.3	6.9**
Statistics	0.5	0.7	0.5	0.7	0.3	0.5	0.2	0.5	0.0
Other topics	1.5	0.9	1.6	0.8	1.9	1.4	1.8	1.3	8.4**
Knowledge	5.3	1.7	5.6	1.6	5.0	1.9	4.5	1.9	11.3**
Comprehension	6.0	2.1	6.2	2.0	5.6	2.0	5.1	2.0	7.4**
Higher abilities	5.1	2.1	5.5	1.8	5.0	1.9	4.5	1.9	11.9**
Total score	16.5	4.7	17.3	4.3	14.8	4.7	13.3	4.6	15.8**

* $p < 0.01$

From Table 6 it may be seen that females achieved better than males within the framework of the BSCS curriculum. The reverse results were obtained for the Non-BSCS students. It may be concluded that while the BSCS brings about a higher level of achievement to all students, it is especially beneficial for the girls.

A similar effect was exerted by the curricular bias of teachers toward the BSCS (Table 8a). Apparently either an inquiry curriculum or an inquiry approach promote a higher achievement among girls.

Table 6a: Mean scores with significant three way interactions among sex, type of school and type of curriculum

Group →	BSCS						Non-BSCS						F interaction df=2,977
	Males			Females			Males			Females			
	T_1	T_2	T_3	T_1	T_2	T_3	T_1	T_2	T_3	T_1	T_2	T_3	
Topic ↓ N	119	28	47	172	14	28	110	149	15	141	158	8	
Statistics	0.6	0.4	0.4	0.6	0.1	0.8	0.3	0.3	0.3	0.1	0.3	0.5	7.1**
Other topics	1.4	1.7	1.6	1.6	1.2	1.6	1.9	1.5	1.3	1.6	1.2	1.5	3.1*

* $p < 0.05$ ** $p < 0.01$

Table 6a shows that regarding achievement in statistics the order for girls from top to bottom is BSCS-kibbutz, BSCS-city, Non-BSCS kibbutz, Non-BSCS agricultural, BSCS agricultural and non-BSCS city. For boys, however, the order is as follows: BSCS city, BSCS agricultural and kibbutz, non-BSCS in all three types of schools. In a similar manner the pattern for "other topics" can be worked out.

The interactions reported above indicate that a certain approach may prove useful under specific conditions for specific topics, while another approach may be more desirable for other topics under the same conditions, or for the same topics under different conditions.

IV Teachers attitude toward the BSCS approach

Table 7 compares the achievement of students studying from teachers who have expressed positive attitudes toward the BSCS approach with those who hold less positive attitudes toward this approach. The dividing line between these two groups of teachers was the mean national score on the Blankenship inventory. Those scoring above the mean are designated as "supporters" while those in the other group as "non-supporters".

Table 7: Mean achievement scores of students of supporters and non-supporting teachers.

Topic ← Group	Supporters N=401		Non-Supporters N=588		F df=1,986
	$\bar{X}$	S.D.	$\bar{X}$	S.D.	
Human biology	2.1	1.0	2.0	1.0	4.7*
Botany	5.0	1.9	4.6	1.8	11.5**
Zoology	4.5	1.6	4.2	1.8	4.3*
Heredity	2.3	1.5	2.1	1.4	2.5
Statistics	0.4	0.7	0.3	0.6	3.8*
Other topics	1.5	0.8	1.5	0.8	0.3
Knowledge	5.2	1.8	4.9	1.9	7.2**
Comprehension	5.8	2.1	5.5	2.1	5.7*
Higher abilities	4.8	2.1	4.3	2.0	9.2**
Total score	15.9	4.8	14.8	4.8	12.6**

* $p < 0.05$ ** $p < 0.01$

Table 7 reveals significant differences in most areas all in favor of the supporters' students. It may be concluded that regardless of the curriculum followed an approach congruent with that of the BSCS yields higher achievement.

Table 8 presents the achievement of supporters and non-supporters' students in different types of schools.

Table 8: Mean achievement scores of Supporters and Non-Supporters in different types of schools.

Topic ↓ / Group →	Supporters			Non-Supporters			F interaction df=2,983
	T_1 N=212	T_2 N=125	T_3 N=64	T_1 N=330	T_2 N=224	T_3 N=34	
Human biology	2.4	1.6	2.3	2.8	2.8	1.5	7.4**
Botany	5.8	3.3	5.7	5.2	3.7	4.6	12.3**
Zoology	5.1	3.4	4.6	5.9	3.5	2.8	13.8**
Heredity	2.7	1.3	2.8	2.3	1.9	1.9	18.3**
Statistics	0.4	0.4	0.6	0.4	0.3	0.1	7.3**
Other topics	1.7	1.3	1.7	1.6	1.4	1.3	2.9
Knowledge	5.8	4.0	5.8	5.4	4.3	4.0	11.9**
Comprehension	6.6	4.4	6.2	6.3	4.6	4.2	11.9**
Higher abilities	5.7	2.9	5.7	4.9	3.6	3.9	24.0**
Total score	18.0	11.4	17.7	16.6	12.4	12.1	24.6**

T_1 city; T_2 agricultural; T_3 kibbutz

** $p < 0.01$

Table 8a: Achievement of male and female students of supporters and non-supporters

Group / Topic	Supporters				Non-supporters				F interaction
	males N=186		females N=215		males N=282		females N=306		
	$\bar{X}$	S.D.	$\bar{X}$	S.D.	$\bar{X}$	S.D.	$\bar{X}$	S.D.	df=1,985
Human biology	2.1	1.1	2.2	1.0	2.0	1.0	2.0	1.0	0.3
Botany	5.0	1.8	5.0	1.9	4.8	1.8	4.4	1.9	3.0
Zoology	4.4	1.6	4.5	1.7	4.5	1.8	4.0	1.7	6.4**
Heredity	2.2	1.4	2.4	1.5	2.2	1.4	2.1	1.4	1.4
Statistics	0.5	0.7	0.3	0.6	0.3	0.5	0.3	0.6	4.4*
Other topics	1.6	0.9	1.5	0.8	1.6	0.9	1.4	0.9	2.3
Knowledge	5.2	1.8	5.3	1.8	5.1	1.9	4.7	1.9	4.0*
Comprehension	5.8	2.0	5.9	2.1	5.7	2.1	5.3	2.0	2.8
Higher abilities	4.8	2.0	4.8	2.2	4.5	2.0	4.2	2.0	1.7
Total score	15.8	4.7	16.0	5.0	15.3	4.8	14.2	4.8	4.1*

* $p < 0.05$ ** $p < 0.01$

As may be seen in Table 8 significant interations occurred in all areas.

In kibbutz and city schools students of supporting teachers achieved better all along the line. An interesting exception is the higher achievement of city non-supporting students in human biology.

In agricultural schools, on the other hand, with the exception of statistics, students of non-supporters achieved better. It may be concluded that as far as achievement is concerned a BSCS approach would yield higher achievement in city and kibbutz schools but not so in agricultural schools.

V The interaction between the type of curriculum and the curricular approa

The most distinctive feature of the present study is the study of the interaction effect between the type of curriculum studied and the teachers' attitude toward the BSCS philosophy. This interaction is especially interesting in the light of the main effects reported above. A two way analysis of variance revealed statistically significant interactions in most areas (F values of 7.8**, 3.8*, 18.6**, 4.3*, 9.8**, 6.8** were found for botany, zoology, heredity, statistics, other topics and the total score respectively). Hence, it was decided to divide the students into four groups, namely Non-BSCS-Non-Supporters, Non-BSCS-Supporters, BSCS-Supporters and BSCS-Non-Supporters. Table 9 compares the achievement of these four groups.

Table 9: Achievement of various groups

Group	1 Non-BSCS Non-supporters N=433		2 Non-BSCS supporters N=148		3 BSCS supporters N=253		4 BSCS Non-supporters N=155		F	t					
Topic	$\bar{X}$	S.D.	$\bar{X}$	S.D.	$\bar{X}$	S.D.	$\bar{X}$	S.D.	df=3,985	1:2	1:3	1:4	2:3	2:4	3:4
Human biology	1.9	1.0	1.9	1.0	2.3	1.0	2.1	1.0	7.3**	0.2	4.3**	2.2*	3.4**	1.9	1.2
Botany	4.4	1.9	4.2	1.9	5.5	1.7	5.0	1.7	25.9**	1.0	8.0**	3.7**	6.9**	3.8**	3.0**
Zoology	4.2	1.8	4.0	1.6	4.7	1.6	4.4	1.7	7.4**	1.1	4.1**	1.5	4.3**	2.2*	1.7
Heredity	1.9	1.4	1.7	1.3	2.7	1.4	2.7	1.3	32.2**	1.7	7.1**	6.6**	7.1**	6.8**	0.3
Statistics	0.2	0.5	0.3	0.5	0.5	0.5	0.6	0.7	18.7**	1.2	4.8**	5.8**	3.0**	4.3**	1.5
Other topics	1.5	0.9	1.4	0.9	1.6	0.8	1.4	0.9	3.5*	1.8	1.4	1.6	2.7**	0.1	2.6**
Knowledge	4.8	1.9	4.7	2.0	5.6	1.5	5.3	1.9	13.5**	0.5	2.8**	4.8**	6.1**	2.6**	1.9
Comprehension	5.5	2.1	4.9	1.9	6.4	2.0	5.7	2.1	18.5**	2.9**	5.8**	1.2	7.4**	3.4**	3.2**
Higher abilities	4.0	2.0	3.9	2.0	5.3	2.0	5.3	1.8	40.3**	0.3	8.7**	8.1**	6.8**	6.6**	0.1
Total score	14.2	4.8	13.5	4.5	17.3	4.4	16.3	4.6	33.7**	1.6	8.6**	4.8**	8.2**	5.3**	2.1*

* $p < 0.05$ ** $p < 0.01$

The most important trends apparent from Table 9 are the following:

- There exist only slight differences between Non-BSCS supporters and non-supporters, but the general tendency is toward somewhat higher achievement of students of non-supporters.
- BSCS students achieved better than Non-BSCS students whether they studied from supporting or non-supporting teachers.
- Student of BSCS supporters achieved best.

It may be concluded that while the nature of the curriculum has been decisive, a congruence between the nature of the curriculum and the attitudes of teachers toward its philosophy are required for an optimal effect. The effect of such congruence is demonstrated by the higher achievement of the BSCS students of supporting teachers as well as by the trend (although much weaker than the previous one) for Non-BSCS student of non-supporting teachers to achieve better. Hence, special efforts should be invested in ascertaining that the attitudes of teachers who adopt a new curriculum are congruent with the philosophy of this curriculum.

Separate comparisons were conducted among the four groups of students in the three different types of schools. (Tables 10,11,12).

Table 10: Achievement of various groups in agricultural schools

Group→	1 Non-BSCS supporters N=83		2 Non-BSCS Non-sup- N=224		3 BSCS N=42		F df= 3,345	t		
Topic ↓	$\bar{X}$	S.D.	$\bar{X}$	S.D.	$\bar{X}$	S.D.		1:2	1:3	2:3
Human biology	1.6	0.9	1.6	0.9	1.7	1.0	0.0	non significant		
Botany	3.3	1.7	3.7	1.8	3.5	1.4	1.2	non significant		
Zoology	3.3	1.5	3.5	1.7	3.5	1.4	0.4	non significant		
Heredity	1.3	1.1	1.9	1.4	1.3	1.0	5.3**	3.6**	0.3	3.3**
Statistics	0.3	0.5	0.3	0.5	0.5	0.7	2.8*	1.1	1.5	2.2*
Other topics	1.2	0.8	1.4	0.9	1.5	0.8	1.9	non significant		
Knowledge	3.8	1.6	4.3	1.9	4.4	1.2	1.4	non significant		
Comprehension	4.3	1.8	4.6	1.9	4.7	2.0	0.5	non significant		
Higher abilities	2.9	1.6	3.6	2.1	2.9	1.0	4.0**	3.2*	0.0	3.5**
Total score	11.0	3.5	12.4	4.7	12.0	3.0	2.2*	2.8**		

* $p < 0.05$ ** $p < 0.01$

Table 11: Achievement of various groups in Kibbutz schools

Group → / Topic ↓	1 Non-BSCS supporters $\bar{X}$	S.D.	2 Non-BSCS-Non supporters $\bar{X}$	S.D.	3 BSCS Supporters $\bar{X}$	S.D.	4 BSCS Non-supporters $\bar{X}$	S.D.	F df= 3,94	t 1:2	1:3	1:4	2:3	2:4	3:4
Human biology	1.8	1.0	2.0	1.2	2.5	1.0	1.3	1.0	8.7*	0.5	2.7*	1.3	1.2	1.4	5.0**
Botany	4.5	1.5	5.9	0.4	6.1	1.5	4.2	1.6	11.8**	3.4**	3.8**	0.6	1.1	4.9**	5.1**
Zoology	3.8	1.2	4.4	1.4	4.9	1.7	2.4	1.8	13.5**	1.0	2.8**	3.1**	0.8	3.2**	5.9**
Heredity	2.3	1.4	0.3	0.5	2.9	1.4	2.3	1.3	8.6**	5.0**	1.5	0.0	9.8**	6.7**	1.9
Statistics	0.6	0.7	0.0	0.0	0.6	0.7	0.1	0.3	4.9**	3.1**	0.1	2.4*	5.7**	1.8	4.0**
Other topics	1.1	0.8	1.9	0.7	1.9	0.7	1.1	0.7	7.7**	2.2*	3.2**	0.0	0.0	2.4*	4.1**
Knowledge	4.3	1.5	5.6	1.0	6.3	1.7	3.6	1.6	18.7**	2.4*	4.4*	1.4	1.7	4.1**	7.0**
Comprehension	5.1	1.8	4.6	1.9	6.7	1.9	3.8	2.3	13.6**	1.3	3.8**	1.3	1.4	2.4*	5.7**
Higher abilities	5.1	1.8	3.1	0.9	5.9	2.0	4.1	1.7	7.9**	3.5**	1.4	1.8	6.2**	2.1*	3.9**
Total score	14.0	3.3	14.4	2.4	18.9	4.4	11.6	4.8	18.9**	0.3	4.6**	2.0*	4.1**	2.2*	6.6**

* $p < 0.05$ ** $p < 0.01$

1N = 16; 2N = 7; 3N = 48; 4N = 27

Table 12: Achievement of various groups in city schools

Topic ↓	Group 1 Non-BSCS supporters N=49 $\bar{X}$	S.D.	2 Non-BSCS Non-supporters N=202 $\bar{X}$	S.D.	3 BSCS Supporters N=163 $\bar{X}$	S.D.	4 BSCS Non-Supporters N=128 $\bar{X}$	S.D.	F df= 3,538	t 1:3	1:4	2:3	2:4	3:4
Human biology	2.3	1.0	2.5	1.0	2.4	0.9	2.3	1.0	0.9	non significant				
Botany	5.7	1.3	5.2	1.7	5.8	1.4	5.2	1.7	7.5**	2.5*	0.4	2.4*	4.3**	0.0	3.7**
Zoology	5.3	1.1	4.9	1.3	5.0	1.4	4.9	1.4	1.1	non significant				
Heredity	2.0	1.5	1.9	1.3	3.0	1.3	2.8	1.3	22.8**	0.4	4.0**	3.2**	7.5**	5.8**	1.0
Statistics	0.1	0.3	0.2	0.5	0.5	0.8	0.7	0.7	19.9**	1.4	4.3**	7.2**	3.6**	6.9**	2.9**
Other topics	1.9	0.9	1.7	0.8	1.6	0.8	1.5	0.9	3.3*	1.1	1.8	2.4*	1.1	2.4*	1.3
Knowledge	6.2	1.8	5.3	1.8	5.7	1.5	5.6	1.7	4.0**	3.0**	1.8	1.9	2.1*	1.4	0.4
Comprehension	6.1	1.4	6.4	1.9	6.7	1.8	6.1	1.8	3.4*	1.5	2.7*	0.2	1.6	1.4	2.9*
Higher abilities	5.2	1.8	4.4	1.8	5.8	1.7	5.6	1.7	22.4**	2.8**	1.9	1.2	7.5**	6.1**	1.0
Total score	17.5	3.4	16.1	4.2	18.2	3.7	17.3	3.9	8.5**	2.4*	1.2	0.3	5.0**	2.6*	1.9

* $p < 0.05$ ** $p < 0.01$

The superior achievement of students of BSCS supporters appears to hold for city and kibbutz schools but not for agricultural schools where Non-BSCS Non-supporters achieved somewhat better than BSCS supporters in heredity, somewhat less in statistics and equally poor in the other areas. In fact there were no teachers in agricultural schools who taught a BSCS course and at the same were opposing its philosophy (Table 10).

There is a tendency for higher achievement of the Non-BSCS Non-supporters compared with Non-BSCS supporters. This result suggest that a Non-BSCS approach may be more congruent with a Non-BSCS curriculum thereby yielding a higher level of achievement. This is especially true regarding achievement in the topic heredity which requires a relatively higher facility in the use of higher abilities. Regarding the BSCS, no teachers who are non-supporters of its philosophy were using it in agricultural schools. Even students taught by BSCS supporters hardly reached the achievement level of students of Non-BSCS Non-supporters. This shows that the BSCS curriculum as well as its approach may not offer any advantage to students in agricultural schools.

Among the three other groups there were few significant differences but an obvious trend of students of Non-BSCS supporters for a lower achievement. Thus, while the BSCS curriulum appears to offer no advantage for agricultural school students, the BSCS approach appears to have a distinct negative effect on the achievement of students who attend agricultural schools.

The results of kibbutz students (Table 11) indicate that a BSCS curriculum had better not be taught by teachers who disagree with the BSCS philosophy. Here the achievement of students of BSCS supporters is by far superior to that of all other groups, in kibbutz schools as well as in other types of schools. While the students of BSCS supporters maintain their superiority also in city schools, the differences between the various groups in city schools compared with kibbutz schools are much smaller (Table 12). Here students of the Non-BSCS-Non-supporters achieved less than the other three groups including that of Non-BSCS supporters. It appears as if the BSCS approach has been more useful for the more select students in city schools even when their teachers have

been unable to use the BSCS materials. It is well known in Israel that in certain city schools the adoption of the BSCS materials is delayed by administrators in spite of the readiness for such adoption on the part of the teachers. In many such occasions BSCS materials have been informally and partially used.

Discussion and Conclusions

The major purpose of the present study was to assess the effect of the BSCS on students' achievement. It is different than previous studies in the following aspects:

1. It has been carried out in a country in which a local adaptation of the BSCS program has been gradually adopted during a long period of time (ten years) on a voluntary basis. Consequently, by the year 1973 about half of the high school students in the country were following the BSCS program (using the local adaptation of the BSCS Yellow Version and the BSCS second course) while the rest of the students were following a Non-BSCS course. Both of these courses were equally accredited by the externally administered matriculation examination which serves as a prerequisite for admission into institutions of higher education. The teachers teaching the BSCS do not differ from the rest either in their preparation nor in other qualifications.

2. It has assessed the effect of studying high school biology not for one year, as has been the case in previous studies in the U.S., but rather for four years. The probability of exerting a long lasting effect is much greater when a certain program is followed for four years.

3. It has addressed itself to a long argued, but hitherto never reached an issue, namely the relative effect of the nature of the curriculum on the one hand and that of the teachers' attitude to the philosophy of that curriculum on the other hand. Quite often when no significant differences could be detected between groups following a "new" and groups following "traditional" programs it has been suggested that, perhaps, the teachers failed to teach along the guidelines of the new programs even though their students were using the new texts. In the present study a deliberate attempt has been made to differentiate between the two effects as well as to study their interactions.

4. Not only the teachers' philosophy but other probable intervening variables such as the type of school, the nature of the subject matter and the sex of the students were studied. The main effects of these variables as well as their interactions have also been explored.

A short discussion of the results follows each table. Here only the major findings and conclusions will be summarized:

1. Students in city schools achieved best, in kibbutz schools next and in agricultural schools last, this regardless of the curriculum followed.

2. Like in most previous studies males performed in most areas better than females. However, females achieved as well as males in certain topics such as heredity and human biology. A highly significant effect of the school type exists: girls in agricultural schools achieved very poorly while girls in kibbutz schools tended to achieve best. In city schools both boys and girls achieved equally well in most areas. It may be concluded that the apparent lower achievement of girls reflects the poor achievement of girls in agricultural schools since they comprise one third of all the girls in our sample. The appropriate conclusion is that, with the exception of agricultural schools where girls achieved significantly less than boys, in other types of schools girls achieved as well and in certain areas even better than boys.

3. BSCS students achieved in most areas and all taxonomy levels much better than non-BSCS students. It may safely be concluded that regardless of other benefits which may accrue as a result of studying a BSCS type biology, as far as content learning is concerned the BSCS appears to be superior. There is one exception, however, to this generalization - the BSCS does <u>not</u> yield better achievement in agricultural schools in most topics. As far as girls are concerned the BSCS yields a lower level of achievement in agricultural schools.

4. Significant interactions have been reported. These interaction effects suggest that a certain program or a certain approach may prove useful for a certain kind of students under specific conditions for specific topics while another program or another approach may be more desirable for another kind of students, or for other topics under the

same conditions or for the same topics under different conditions.

5. Regardless of the curriculum followed, students of teachers holding favorable attitude to the BSCS philosophy achieved better. Hence, not only an inquiry oriented curriculum yields a higher level of content learning but an inquiry oriented approach leads in the same direction. Here again students in agricultural schools are an exception: not only they achieved less by studying the BSCS curriculum, but even a BSCS approach appears to be inappropriate.

6. From the point of view of educational research, the most significant finding of the present study relates to the interaction between the type of curriculum used and the curricular attitudes of the teachers. It may safely be concluded that for most students studying a BSCS program from a BSCS supporting teacher yields the highest level of achievement.

7. The present results indicate that out of the two variables, namely the nature of the curriculum on the one hand and the attitude of the teachers on the other hand, the first is the more decisive. Perhaps this result may be explained by the fact that even the non-supporting teachers were not holding totally negative attitudes toward the BSCS philosophy but rather a less positive one. Hence at least in certain issues their attitudes might have been supportive rather than inhibitive. While the nature of the curriculum is more decisive a congruence between the nature of the curriculum and the teachers' attitudes towards its philosophy are required for reaching an optimal effect.

To sum up, the major implications of the study are the following:

a. Unlike most available studies which report no significant differences in achievement between BSCS and non-BSCS students, this study shows a remarkable superiority to the BSCS curriculum. The reason may very well be the length of time necessary for producing a significant impact: in all previous studies the longest study period was one school year as compared with four years in the present study.

b. That student study according to a particular curriculum does not tell the whole story. There are significant effects

to other independent variables. Two such variables which exert a strong effect are the teachers' philosophical bias toward the curriculum as well as the school environment.

c. For obtaining the highest achievement one should ascertain the availability of a combination of favorable conditions such as a more effective curriculum, teachers who support a progressive instructional approach and an appropriate school environment.

d. More useful information may be obtained by studying effects on achievement as reflected not just by a single total score but also by assessment of specific topics and cognitive abilities.

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